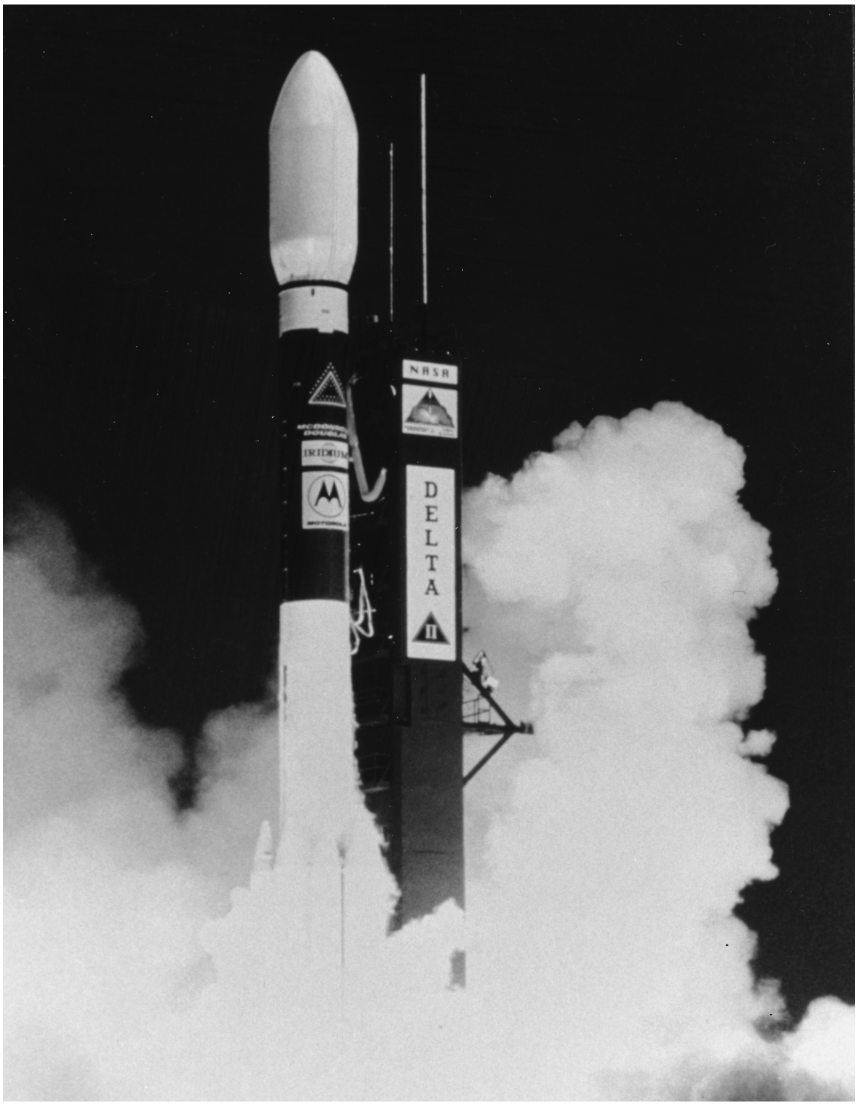
The Iridium Network

Mobile telephony via satellite

Proliferation of mobile phones is already a fact, but worldwide mobile telephone communication has become possible only with the advent of the Iridium Network. The network is a joint venture between US organizations Motorola and Lockheed Martin Corporation, and the Russian Krunichev State Research Space Centre. The first satellites were launched towards the end of last year; when fully operational, the network will embrace 66 satellites in various orbits around the earth at a height of some 780 kilometres (470 miles). This fairly low orbit is dictated by the relatively low power of mobile phones.

By our Editorial Staff



INTRODUCTION

Iridum is the first truly worldwide functioning satellite telephone system. The name 'Iridium' was chosen because the original concept of the network envisaged 77 satellites and iridium, a metallic element of the platinum family, is number 77 in the Periodic System. Although the final network will consist of 66 satellites (plus six spare), the name was retained, probably because the element at number 66 of the Periodic System, dysprosium, a member of the rare-earth group, is a rather more difficult name to remember.

Basically, the system works as follows. A call from a mobile phone is transmitted to the nearest Iridium satellite, from where it is relayed to another satellite in the system which is nearest the call's final destination. From this, the signal is beamed down to another cellular phone or a traditional line telephone.

Not many people may have noticed it, but the first Iridium satellite was taken into operational use a couple of months ago. With this, a concept that at its birth 11 years ago was dubbed 'science fiction' by many, became reality.

Many aspects of the network are new (at least as far as non-military use is concerned).

- Instead of some large geostationary satellites, it uses a fairly large number of smaller ones in low orbits.
- All satellites are in communication with each other and so form a truly worldwide network.
- Mobile phones and pagers anywhere in the world can be accessed directly by the relevant satellite, which means that the system is independent of terrestrial infrastructures.
- The system is compatible with all current terrestrial mobile telephone networks, such as GSM (Global System for Mobile Communication) in Europe, IS-95 in the USA, PDC in Japan, and others. This means that from now on a GSM user can communicate with an IS-95 user (which until recently was impossible).
- An Iridium subscriber can be contacted from anywhere in the world on just one number – which may be his/her current mobile phone number.

LEO/MEO VS GEO

Until Iridium became operational, civil satellite communications were conducted almost exclusively by geostationary (GEO) satellites about 36 000 km (almost 22 000 miles) above the earth. Exceptions were, for instance, the television satellites in the former Soviet Union which, to cover the extreme north of the country, were in highly elliptical orbit.

The Iridium Network is the first civil communication system that uses satellites in low-earth orbit (LEO) and medium-earth orbit (MEO), which lie between 700 km (425 miles) and 10 000 km (about 6 000 miles).

The difficulty with using high-orbit satellites is not so much the requisite high (transmitter) power or more sensitive receivers in the mobile phones (which would become much larger), but rather the signal delay, particularly in the case of digital equipment. The only satellite telephone service prior to Iridium was via the geostationary Inmarsat satellite which uses equipment the size of a briefcase and requires the antenna to be directed at the satellite. As Inmarsat will continue their GEO service, they have indicated that the user equipment will be drastically reduced in size.

Other planned systems – see overview in Table 1 – will, however, use LEO and MEO satellites.

The LEO satellites in the Iridium Network orbit the earth in about 100 minutes. Motorola's future system, Celestri, is planned to use LEO as well as MEO satellites. This system will provide video, interactive multimedia, and data services.

Another system of the future, Microsoft's Teledesic, is planned to become an Internet satellite network.

A quite different approach is that of Ellipso, which is intended for communications over the northern hemisphere, supplementing terrestrial services. This network will use highly-elliptical orbit (HEO) satellites, the height of whose orbit will vary from 500 km (300 miles) to 8 000 km (almost 5 000 miles).

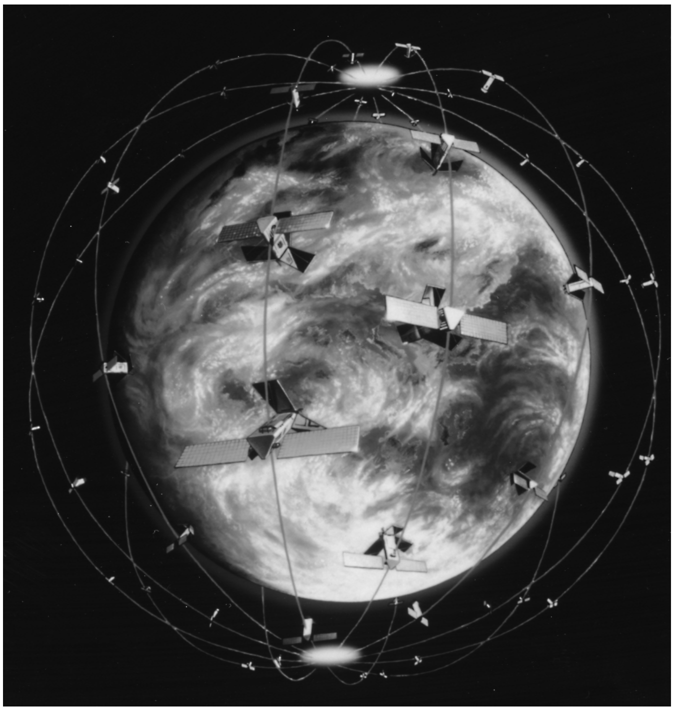


Figure 1. The 66 operational satellites in the Iridium Network use six different orbits to provide worldwide communications.

THE IRIDIUM NETWORK

The Iridium system embraces 66 operational and six spare satellites. It is planned to have a life of 5–8 years. To enhance the reliability of the system, a number of additional satellites have been put into orbit, which enable a number of control centres to monitor the movements and working of the operational satellites in their orbits. The main monitor centre in Landsdown, Virginia, USA, is supported by fixed monitor stations in North Canada and Hawaii, and a transportable one in Iceland.

Each satellite is in contact in four directions with other satlelites in the system in the Ka-band (18–30 GHz).

The satellites are linked to the terrestrial networks by twelve gateways (earth stations) on four continents. Three or four 3-metre diameter rotary parabolic antennas track the high-speed (29 000 km/h – 17 500 mph) satellites and transfer voice and data information. Communication between the control satellites and the gateways is in the Ka band (down-link 19.4–19.6 GHz; uplink 29.1–29.3 Ghz).

The gateways pass the information to the relevant terrestrial network (and convert the used protocol if necessary) and also manage and store any information for relay to Iridium pagers. The European gateway is at Fucino in Italy.

Communication between the operational satellites and the providers of the mobile phone and pager services is in the L-band: 1616–1625.5 MHz. The same frequencies are used for the up and down links, which allows the same components to be used for transmitter and receiver.

As an aside, the use of L-band downlink frequencies is likely to cause problems for radio astronomers, since they are very close to one of the spectral lines (1612 MHz – the others are at 1665, 1667, and 1720 MHz)) of the hydroxyl molecule (HO), which is one of the most important frequencies for radio astronomers.

Name of system	Operator	Satellites	Planned for
Inmarsat	Inmarsat	12 GEO	Late 1999
Globalstar	Global Star	64 LEO	Late 1999
ICO	ICO Global Communications	12–15 MEO	2000
Spaceway	Hughes Communications	12–20 GEO	2000
Celestri	Motorola	63 LEO/GEO	2001
Odyssey	TRW/Teleglobe	12 MEO	2001
Skybridge	Alcatel Alsthom	64 LEO	2001
Teledesic	Microsoft	288 LEO	2002
Ellipso	Mobile Communications	17 HEO	2002

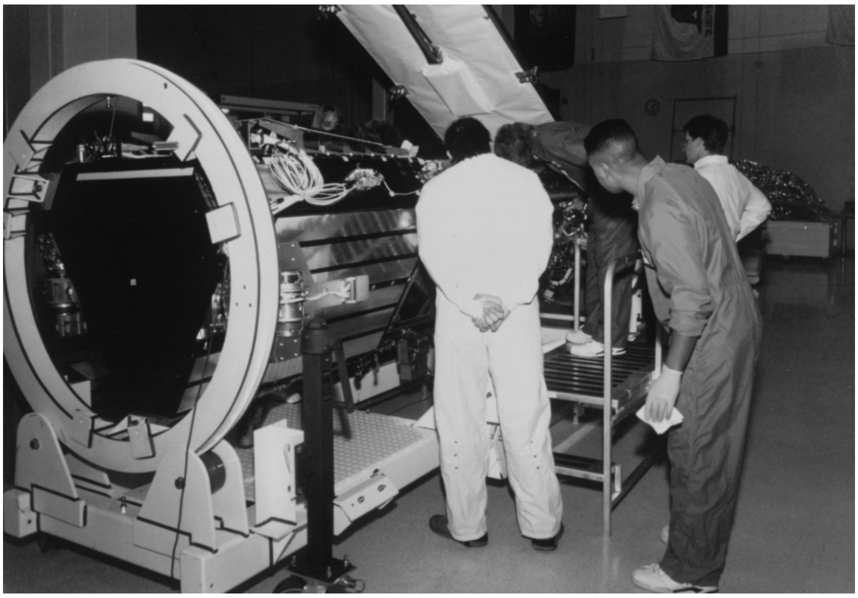


Figure 2. Assembly of the nearly 700 kg weighing satellite at the Motorola-SATCOM plant in Chandler, Arizona. Note the triangular cross-section of the carrier structure which is made of reinforced man-made fibre.

MOBILE PHONES AND PAGERS

The mobile phones and pagers are manufactured by Motorola and Kyocera. The mobile phones are very similar to those used on GSM networks and are able to operate not only with the Iridium standard, but also on a number of other standards, such as GSM and IS-95.

The two designs are quite dissimilar. The Motorola phone is primarily intended for use in the Iridium system, which can be expanded by an optional cassette (which can be slotted into the phone) for use in terrestrial mobile phone services. Each different standard requires a different cassette, for instance, in Europe, a 900 MHz or 1800 MHz GSM model; in the USA, Africa and Russia, an 800 MHz IS-95 version.

The phone weighs about 450 grams. In satellite service, its average transmit power is 645 mW, but there is a link margin of about 15.5 dB. The current price, including one cassette, is about $US3,000.

The Kyocera design is quite different, almost the opposite of the Motorola phone. Its handset, which weighs only 80 grams, is intended primarily for use in terrestrial mobile phone systems. If communication via satellite is required, the handset is inserted into a special ‘docking station’: the combination weighs 450 grams. When the user travels from an area with a different service standard, a second handset is needed. The docking station and batteries can be used irrespective of which standard prevails.

PAGING VIA IRIDIUM

The Irridium Network is not only the first global mobile telephone service, but it also offers the first paging service that ensures accessibility anywhere in the world without a mobile phone or with the mobile phone switched off. The message sender need not know where the recipient is as this is automatically established by the Iridium system (provided, of course, that the pager is switched on). The Iridium Paging Service allows alphanumeric mes-

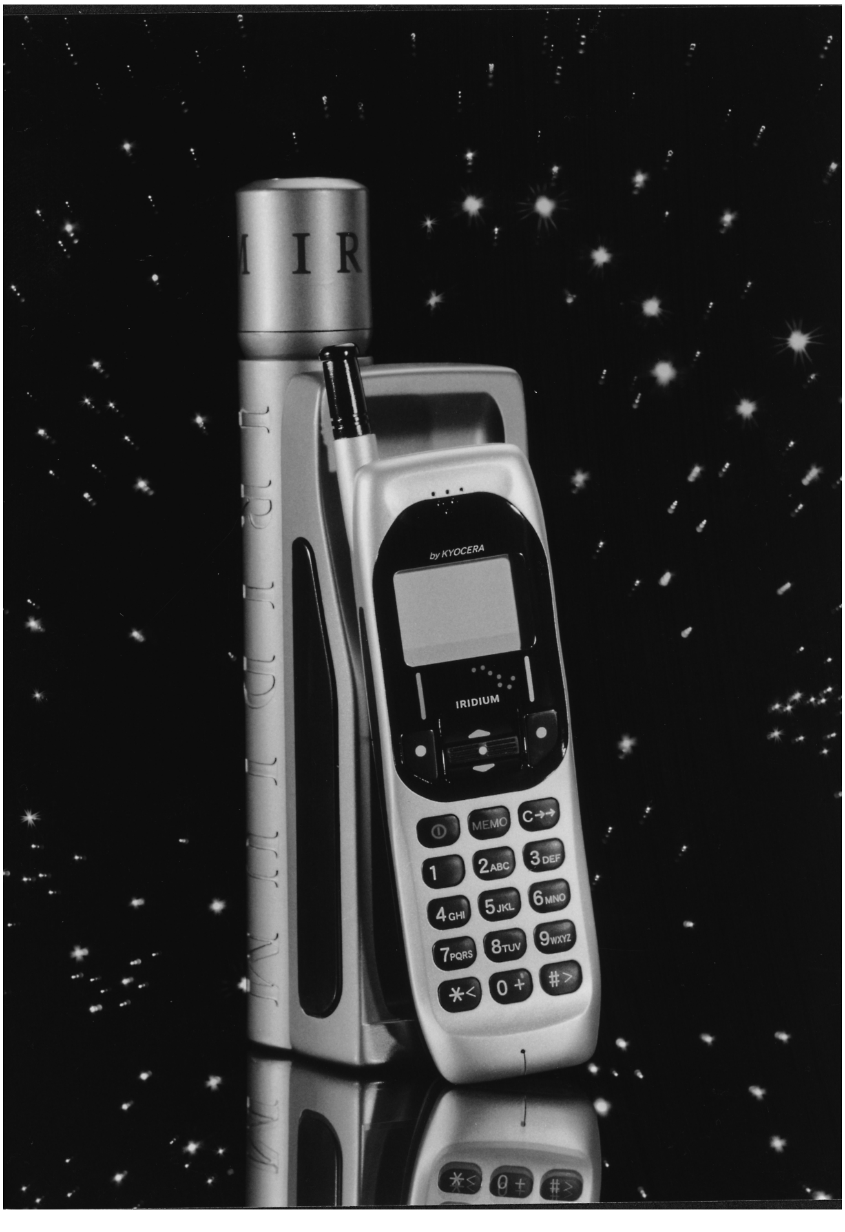


Figure 3. The Kyocera Iridium phone cosists of a handset intended for terrestrial services which is transformed into a satellite mobile phone by inserting it into a ‘docking station’ with L-band antenna.

sages of up to 200 characters as well as numerical ones of up to 20 ciphers. The pager specifications embrace international graphic characters and LED displays. There is an optional possibility of sending a message to groups of addresses. The batteries last for about 30 days.

OPERATORS AND PROVIDERS

Although the design of the equipment was carried out by Motorola and that of the satellites by Lockheed Martin, the Iridium Service is operated by Iridium LLC. This is an international consortium of communication companies and other industrial organizations, including Motorola, Lockheed Martin, British Aerospace, INMARSAT, and others, which have invested in the development and marketing of the Iridium service.

The consortium has representatives in 15 countries all over the world. At the time of writing, it had concluded about 300 agreements with service providers and roaming partners, which together represent more than 100 million customers in 122 countries. Further agreements in more than 100 countries are confidentally expected within the first few months of this year.

Users of current mobile phones can obtain information on the Iridium service, and possibly relevant handsets, from their current provider. Billing for the Iridium service is through these providers. Also, they retain their current mobile phone number. People who do not want to use terrestrial mobile phone services can take out a satellite-only mobile phone contract, and this service issues numbers starting with the international code 8816.

[990003]

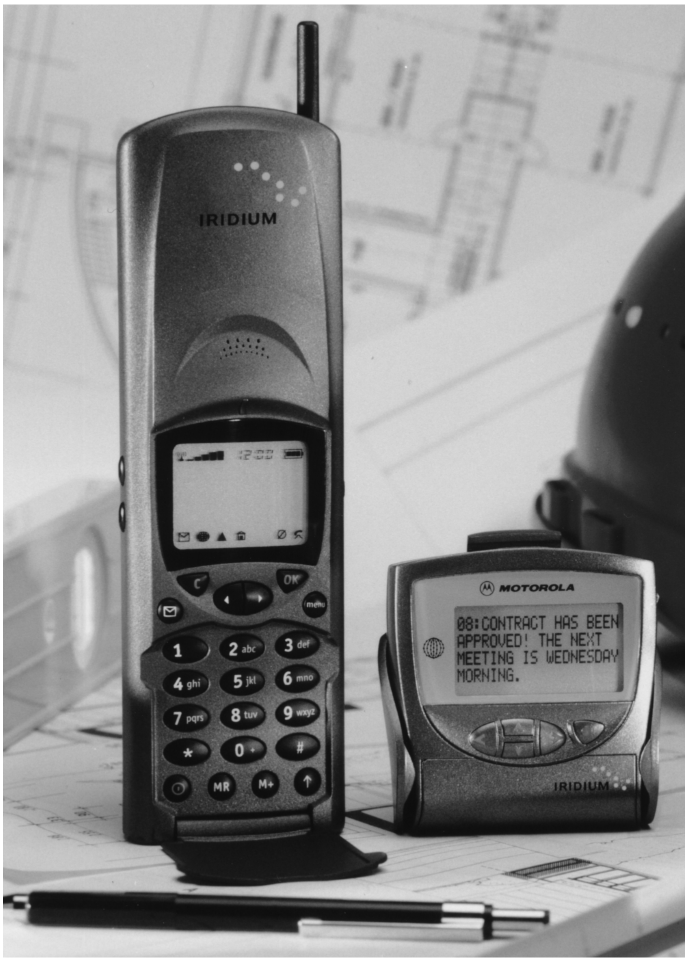
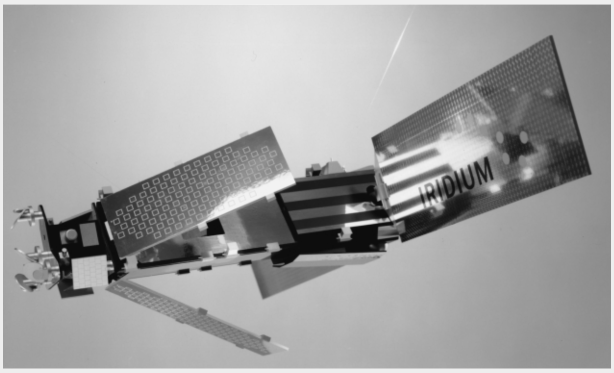

IRIDIUM
MOTOROLA
08:CONTRACT HAS BEEN APPROVED! THE NEXT MEETING IS WEDNESDAY MORNING.
IRIDIUM

Figure 4. Iridium pager and mobile phone from Motorola. The phone has an interchangeable frequency module for a number of mobile phone standards and needs an additional L-band antenna unit for operation in the Iridium Network.

The Iridium Satellites



Each of the 66 operational and fourteen spare and control satellites built so far weighs 689 kilograms (just over 1500 pounds) and is 4.5 metres (just under 15 ft) long. Its power is provided by two wing-shaped panels almost 6 metres (20 ft) long that are fitted with gallium-arsenide solar cells.

The triangular carrier structure is made from reinforced man-made fibre.

The solar generator charges a 22-cell nickel-hydrogen battery, which becomes the power supply when the satellite is in the shadow of the earth (about half the 100 minute orbiting time).

The average transmitter power is 660 W. The central electronics circuits are based on ASICs (Application Specific ICs). The computing power of the multi-processor network is about 100 mips (million instructions per second). At full load, up to 11,000 telephone conversations can be handled simultaneously.

The RF stages of the transmitter and receiver are based on MMICs (Monolithic Microwave ICs), while the amplifiers in the receiver use low-noise GAS-FETs.

Communication in the Ka-band to other Iridium satellites is carried out by four antennas (two North-South and two East-West) on frequencies between 23.18 GHz and 23.38 GHz.

Direct communication with mobile phones and pagers takes place in the L-band between 1616 and 1626.5 MHz via three main antennas and 16 spotbeams.

Communications with the gateways is via four movable antennas in the Ka-band (downlink 19.4–19.6 Ghz and uplink 29.1–29.3 GHz).

All antennas consist of flat panels and use state-of-the-art technology.

As mentioned earlier, the 80 satellites were designed and manufactured by Lockheed Martin. This company has to date built more LEO satellites than any other organization in the western world. In spite of all this experience, there were a number of failures, and these set back the overall program by about six months.

Most of the satellites are launched in groups of five by a Boeing Delta II Rocket from the Vandenberg launch pad in California.

Some satellites were launched in groups of seven by a Russian Proton Rocket from the Baikonur Kosmodrom site in Kazakhstan.

Some satellites will be launched by China, but the Great Walls Industries Corporation's 'Long March 2C/SD' rockets can accommodate only two satellites at a time.

The spare satellites will be launched by Delta II and Long March 2C/SD rockets. At the end of last year, seven of the 14 spare and control satellites were already in orbit.